A Triadic Theory of Elementary Particle Interactions and Quantum Computation (review)

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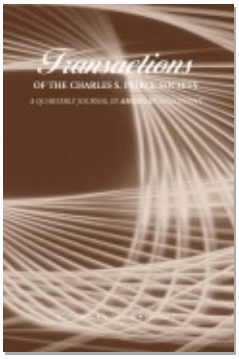

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munity of inquirers (e.g., "Some Consequences of Four Incapacities", "Grounds of Validity of the Laws of Logic"), which will be published as a book by Wydawnictwo Uniwersytetu Opolskiego in 2009.

13. Karl-Otto Apel, *Charles S. Peirce: From Pragmatism to Pragmaticism*, Atlantic Highlands: Humanities Press, 1995 (the quotation is from "Introduction to the Paperback Edition" which is printed on unnumbered pages).

Ralph G. Beil and Kenneth L. Ketner
A Triadic Theory of Elementary Particle Interactions and Quantum Computation
Lubbock: Institute for Studies in Pragmaticism, 2006. 49 pp.

The work and its authors

The book under review is quite an unusual production in more ways than one. It is the fruit of a remarkable collaboration between a theoretical physicist (Ralph Beil) and a well-known philosopher and Peirce scholar (Kenneth Ketner). Beil and Ketner (from now on B&K) are undertaking an ambitious program to develop a new interpretation of quantum theory and ultimately of the entire standard model of particle physics. Their efforts are partially based on Peirce's relational logic along with several of his other philosophical ideas, suitably combined with some original conceptions in theoretical physics which Beil has been proposing since earlier publications. B&K have previously collaborated on a physics article, "Peirce, Clifford and Quantum Theory" (2003)[1] and jointly hold United States Patent 6,819,474 (2004). This patent records their invention of the *trisistor*, a new quantum switching device to be used in quantum computation and conceived as a technological application of ideas advanced in their book.

It is not clear why the authors decided to publish this work as a bound monograph instead of as an article in a professional journal. The length of the text—including figures, tables and bibliography—is scarcely fifty pages, and B&K have not taken advantage of the monograph format by including an index or a supplemental glossary that defines the many and difficult technical terms used. These choices may consequently restrict the potential readership of a work requiring thoughtful examination by physicists and philosophers alike. A future, publicly accessible electronic version would go a long way in remedying these shortcomings.

The Work's Contents

There is a one-page preface, followed by a brief introduction that acquaints the reader with many of Peirce's scientific and philosophical achievements and supplies references for further study. That, with very few exceptions, Peirce's ideas were not influential in the development of

20th century physics is noted. B&K hope to rectify this situation with the introduction of the models advanced in the work at hand. Following an introductory outline is an enumeration of the topics to be covered in the remaining sections II through VII.

Section II outlines Peirce's theory of relations and explains clearly the framework on which the proposed models are built. Emphasis is placed on triadic structures displayed in diagrammatic form, on their paradigmatic instantiation within the sign relation, and on the features of valence and bonding. The irreducibility of triadic to dyadic relations is also emphasized. Peirce's conception of the relational nature of reality and his use of the term *existence* to refer to a special case of reality are also duly explained.

Section III, entitled "Time Symmetry, Advanced Potentials and Needle Radiation," introduces these three concepts through extremely condensed characterizations buttressed with abundant references to the physics literature. Time symmetry refers to the fact that fundamental theories contain no counterpart to our common-sense distinction between the forward and backward directions in time. Advanced potentials result from the associated fact that the equations of classical and quantum electrodynamics admit forward (retarded) as well as backward (advanced) solutions, according to the two time directions. While consideration of these two concepts is quite prominent and of wide-ranging consequences in contemporary philosophy of science, needle radiation (developed by Einstein) is an almost forgotten conception. While spherical radiation propagates in all directions, needle radiation travels along a linear path as a narrow wave bundle of limited extension, thus serving as a model for an elementary particle in the authors' proposals.

Section IV, "Physical Preliminaries," surveys at breathtaking speed several other facts and assumptions on the dispersion and spreading of wave packets, which B&K require for developing a quantum theory concerning individual particles instead of probabilities.

Section V, "Triadic Relations and Elementary Particles," is the centerpiece of the work. B&K conceive elementary particles as chains of bonded signs that are somehow embodied in space-time. These triadic relational structures display two kinds of bonding. The internal bondings represent the history of the particle and connect its "object aspect" (*O*) to its "representamen aspect" (*R*). The external bondings bind the interpretant elements *I*—*I*, thus representing the interaction of the particle with another individual particle. B&K identify interpretants with "observers" without further elaboration. The interacting particles are said to "observe" each other by altering each other's states and carrying away an "interpretation" of the interaction. The *O*—*R* aspect of the particle is an existent real, while the *I* aspect is real but not existent. The interaction of an electron with a photon is illustrated with a generic dia-

gram connecting two triadic structures through the bonding of their *I* links. The authors call this kind of representation a PBK diagram (after Peirce, Beil and Ketner) and note its partial resemblance to standard Feynman diagrams.

B&K seek to establish a direct correspondence between PBK diagrams and features of quantum physics. The *O*—*R* bonds correspond to wave functions, which are solutions of wave equations (e.g., the Maxwell equation for photons or the Dirac equation for electrons). They can be represented by means of the standard bra-ket notation of quantum physics, although the expectation values are not interpreted probabilistically as in standard accounts. Rather, the values are considered amplitudes of field densities associated with individual particles. Taking advantage of the time symmetry of the dynamics, the bra states are interpreted as states propagating from the future to the past, in the tradition of the so-called transactional interpretations of quantum mechanics (i.e., stemming from the works of Costa de Beauregard, Cramer, and others). There are PBK diagrams representing particle-antiparticle annihilations and their time-reversal in the creation of particle-antiparticle pairs. Next follow similar representations of repulsive electromagnetic interactions between electrons, and attractive interactions between electrons and protons, as well as a diagram for the emission of photons from a hydrogen atom.

At this point B&K propose their own account of the internal structure of elementary particles. This is preceded by a strong condemnation of current theories that reject the reality or explainability of such internal structure. B&K indict these standpoints as a "collective fabrication." Their proposed interpretation is based on a modified, generalized form of the Dirac wave equation of a particle, which no longer represents plane waves. This requires the insertion of a form factor associated with an electromagnetic potential, which represents a solution of a classical wave equation. The form factor results from a superposition of retarded and advanced waves and serves to determine the particle's internal structure. The particle's permanent properties (e.g., charge, mass, etc.) are computable from the form factor. The transient properties (e.g., position, momentum, etc.) that the particle may display at varying times are obtained from the entire wave function upon its interaction with other particles.

Through extremely brief and sketchy considerations, with frequent referral to their previous publications, the authors indicate some desirable consequences of their model. The details are too technical to be summarized here, but perhaps the most noteworthy are the model's compliance with well-entrenched laws (e.g., the exclusion principle), the elimination of problems about multiparticle states, and the existence of "antiphotons." These are photons moving backward in time with negative momentum. B&K use these antiphotons to construct a model in which

attractive and repulsive Coulomb forces result from positive or negative momentum transfer between particles. The overall model also displays a built-in nonlocality that helps dispel notorious paradoxes due to an apparent action at a distance between entangled particles.

Section V ends with a depiction of physical reality as a network of triadic structures bonding to each other in space-time and displaying a triple form of continuity. There is an underlying continuity constituted by an all-pervasive medium, a sort of relativistic ether that generates the potentials and form factors. A second kind of continuity binds the web of triads associated with the particles, whose internal structures do not become actualized until they connect to subsequent triads. These internal structures span non-causal links between causally separated triads and are at the root of the physical world's overall nonlocal character at the particle level. A third kind of continuity springs from the superposition of individual wave functions in the formation of multiparticle states. B&K see in these three forms of continuity a vindication of Peirce's Synechism. They also propose an interpretation of the four forces of nature invoked by the standard model of particle physics. In their view the electromagnetic force is fundamental and the others are derivable from it. Few details are given except by reference to previous work written by Beil.

Section VI, entitled "A Triadic Quantum Computer," explains B&K's invention of the *trisistor* (so named in analogy to a transistor), a quantum computer switch that functions by means of elementary particle interactions instead of electric currents. The operation of this device is analyzed by means of PBK diagrams. Several potential embodiments and applications are described as well as the advantages over standard alternatives. Full details are available at the U.S. Patent Office website: http://patft.uspto.gov/ (Patent #6,819,474).

Section VII, "Concluding Remarks," contains a very brief summary of the ideas presented and even shorter remarks on "determinism versus chance," "hidden variables," "action at a distance" and "quantum jumps and collapse of the wave function." B&K note that in their model the uncertainty described by the Heisenberg principle is not related to probabilities but due to the random impacts of elementary particles. Although the form factor is a vehicle of hidden variables the usual objections arising from the Bell theorem are circumvented through the nonlocality of the form factor. The appearance of action at a distance between distantly located entangled particles is due to the interaction of the advanced waves of one particle with the retarded waves of the other. Likewise, the wave function's "collapse" countenanced by some interpretations of quantum mechanics turns out to be merely apparent.

The Work's Contribution to Peirce-Inspired Physics and Philosophy

A thorough assessment of this book must evaluate at least three interrelated areas: a) the application of Peirce's neglected ideas to current physical theory, b) their contribution to the resolution of philosophical issues arising from the extraordinary theoretical and experimental discoveries of physics during the past century, and c) the physical import of some of B&K's proposals which are not directly connected to Peirce's conceptions.

Some characteristics of the work's style and format render this assessment quite difficult. The main obstacles are the extreme brevity and compression of the presentation, the overly sketchy nature of the arguments and the frequent deferral to scattered technical sources—not merely for elaboration but for arguments and occasionally for the very meaning of the terms employed.

In the preface the authors state, "this monograph is written so as to require a background level not far beyond that of the 'intelligent layperson,' either in logic or physics." This reviewer, with decades of university teaching and daily interaction with physicists and other scientists, finds this statement perplexing to the extreme. On the contrary, it seems fair to reckon that most of the book would fall outside the reach of people lacking a solid background in theoretical physics. These and other considerations, such as this journal's potential readership and the personal limitations of this reviewer, suggest focusing the assessment on point b): issues in the philosophy of physics.

The authors are to be congratulated for the audacity of their unorthodox proposals and the sweeping ambition of their theories. These are indeed Peircean virtues. The application of the PBK triadic diagrams to technological devices opens the possibility of gaining experimental support for some of Peirce's ideas. The eventual success of trisistors as computational devices would no doubt awaken interest in Peirce's speculations within philosophy circles and beyond. Synechism and Tychism are invoked more than once in the text, but their bearing on B&K's proposals is not fully articulated.

On the negative side, another of Peirce's virtues fails to shine in this work: his eirenic stance before *prima facie* contradictory ideas and his sympathetic, creative reading of opinions opposed to his own views. Perhaps because of the aforementioned format constraints, B&K have neglected to consider any of the original philosophical views arising from the remarkable proliferation of philosophical interpretations of quantum mechanics that have emerged in the last twenty years. They confine their animadversions to a quasi-mythical "Copenhagen Interpretation," an umbrella-term often applied to radically different and sometimes incompatible theories. Their position seems somewhat aligned with the traditional "hidden variable" interpretations (e.g., the pilot wave and Bohmian mechanics) with suitable modifications

designed to counteract the "no-go theorems" that plagued previous versions. A common trait within these interpretations is the adoption of a traditional variety of philosophical realism and the desire to recover as much as possible of the visualizable character of classical physics, even at the expense of admitting some apparently counter-intuitive features—in our case backward causation.

It is extraordinary that several ideas which Peirce advanced on purely philosophical grounds, were later rediscovered by physicists struggling against recalcitrant experimental findings and their own, often implicit, metaphysical presuppositions. Expressions such as "genuine fortuitousness," "objective fuzziness," "objective indefiniteness," "objective probability," that crop up in current examinations of quantum theory will be easily associated by readers of these *Transactions* with Peirce's doctrines of objective randomness and vagueness. Affinities with Peirce's ideas are found in various current elucidations of quantum mechanics, including Mermin's Ithaca Interpretation, Rovelli's Relational Interpretation, the work of Shimony and Primas, as well as in attempts to base quantum theory on an objective notion of information by Bub, Zeilinger, and others. It is heartily to be hoped that Beil and Ketner's efforts are rewarded in one of their principal goals—that of promoting the application of Peirce's ideas to physics and the philosophy of physics. It is also to be hoped that they succeed in expanding the book's programmatic assertions into a fully articulated theory able to enter into fruitful dialogue with the many new ideas emerging at present.

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NOTE

1. Beil, R. G. and Ketner, K. L., 2003, "Peirce, Clifford, and Quantum Theory." *International. Journal of Theoretical Physics* 42(9): 1945–1959.